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The Effects of Coal Mining on Health in Appalachia:  
Global Context and Social Justice Implications

Adrienne Schmidt

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### Abstract

The purpose of this report is to investigate the environmental and health effects of coal mining in the Appalachian region of the United States in the context of global natural resource extraction, explore existing regulation for the reduction of negative environmental health effects of mining in Appalachia, and explore the social justice implications of current mining practices. The research for this report was limited to literature published in English. It was found that there are widespread negative health effects of mining in Appalachia due to environmental toxins, a toxic social environment of limited economic opportunity, and occupational health hazards. The fate of Appalachia as a national sacrifice zone is often viewed as inevitable by the public, which allows the slow violence of environmental and health degradation to persist. The injustices that occur in Appalachia as a result of coal mining deny Appalachians the right for fair equality of opportunity. Consumers and regulators of coal play a key role in establishing justice in Appalachia.

## The Effects of Coal Mining on Health in Appalachia: Global Context and Social Justice Implications

The Appalachian region of the United States is tightly associated with its major industry, coal mining. Appalachian coal has been mined since the early nineteenth century, and has provided the force behind the regional economy (Harvey, 1986). Despite Appalachia's abundant natural resources, its people have long been plagued with poverty. Widespread absentee land ownership in Appalachia is largely responsible for the disconnect between the high value of Appalachia's coal reserves and the region's poverty. Underground mining was the principal method of coal mining in the region until the mid-twentieth century, when surface mining became dominant (Haskell & Abramson, 2006). Mountaintop removal (MTR), one of several types of surface mining, emerged as a method of coal mining in the 1960s, but did not become prominent until the 1990s when the Clean Air Act was amended, bringing the low-sulfur, high-energy bituminous coal of Appalachia into high demand (Burns, 2007). It is now the major mining method in Appalachia because it grants access to thinner coal seams that were previously unattainable using traditional underground mining methods and other methods of surface mining (Holzman, 2011). It is also preferred by mining companies because it is more highly mechanized, so fewer employees are needed to run the mines (Holzman, 2011). However, the environmental and public health effects of MTR have gained attention in recent decades due to their threat to and increasingly negative effects on nearby populations.

The history of mining conflict in Appalachia is as embedded in the region's identity as mining itself. As miners began to unionize in order to obtain safer working conditions and fair wages, they faced vehement opposition from the coal companies. Between the late 1890s and 1933, there were frequent strikes and violent battles between miners and coal companies. These

conflicts resulted in many deaths, the declaration of martial law, a U.S. Senate investigation, and the involvement of the U.S. Army (Burns, 2007). In 1933 the federal government stepped in to grant workers the right to unionize (Burns, 2007). Many miners unionized after that point, but companies continued to use paternalism and welfare capitalism to foster miners' allegiance to companies rather than the United Mine Workers of America (UMWA). This included adding previously nonexistent perks to life in company towns, including better living conditions with indoor plumbing, soda fountains, mercantiles, religious establishments, and summer camps for kids (Burns, 2007). The UMWA has since experienced fluctuations in membership as a result of a decline in the overall population of miners due to increased mechanization in mining (Burns, 2007).

With the mechanization of mining came increased unemployment, decreasing populations in Appalachia as unemployed miners sought work elsewhere, and decreasing participation in the UMWA. In order to stay afloat, the UMWA began supporting surface mining, and in the 1990s, MTR. This support has created a complicated relationship between underground miners, surface miners, populations living in proximity of MTR mining areas, and politicians (Burns, 2007). Because of the high cost associated with increased mechanization, many small mines cannot afford to remain independent and have been absorbed into multinational coal companies like Massey headquartered in Richmond, VA. These large companies typically resist hiring unionized workers; only 4 percent of Massey's workforce was unionized in 2003 (Burns, 2007). The UMWA has therefore experienced decreased influence in the communities of southern West Virginia. Tension between miners and the UMWA is heightened by bitter sentiments harbored by the UMWA because of their hard-won battles to ensure decent living and working conditions for miners in the early years of mining development

(Burns, 2007). While battles between miners, residents of mining areas, politicians, and mine companies do not still play out with violent shootings and military involvement like they did in the past, mining conflict is no less contentious.

In the 1880s, lawmakers began favoring the interests of industry over the rights of individual citizens in Appalachia as an incentive to promote economic prosperity and settlement in the years following the Civil War (Burns, 2007). Mistakenly thinking resource extraction was the key to wealth, no efforts of economic diversification were made, and a “single-industry, resource-dependent” economy was born, along with a firm power dynamic between industries and individuals (Burns, 2007, p. 2). The legal precedent set by initial attempts to develop Appalachia and their accompanying power paradigm persist today, and led to the currently weak enforcement of mining and environmental legislation in Appalachia, as Rebecca Scott describes:

In the years between 2000 and 2004, the Clean Water Act was rewritten to allow the dumping of waste into streams...it seemed to have become clear to everyone that MTR could not be made to conform to the preexisting environmental laws. MTR is one of those practices occurring at the edge of law that allow for capital accumulation. Because it exists on the edge, debate can remain focused on the legality or illegality of particular cases instead of the more deeply political questions of what the practice is doing to the coalfields. (2010, p. 24-25)

This is a concerning statement considering the appearance of heavy mining and environmental regulation in the United States. The first law governing mining in the United States was passed in 1891. Legislation with the largest impact on current mining practices in the United States includes the Federal Coal Mine Health and Safety Act, passed in 1969, and extensive mining legislation in the Federal Mine Safety and Health Act of 1977, which amended the previous act

(US Department of Labor, 2012). The Mine Improvement and New Emergency Response Act, or the MINER Act, is the most recent law passed regarding mine safety in the United States. The Mine Safety and Health Administration, or MSHA enforces this legislation under the United States Department of Labor (US Department of Labor, 2012). The United States Environmental Protection Agency (EPA) also plays a major role in protecting populations from the negative environmental and health effects of mining activity. Additional legislation affecting mining, particularly MTR, includes the Surface Mining Coal and Reclamation Act enacted in 1977 and the Clean Water Act enacted in 1972 (Burns, 2007). The attitude that current mining practices are beyond the control of the law contributes to lax law enforcement, environmental degradation, and severe health effects of mining activity.

In this paper, I aim to explore the relationship between coal mining in Appalachia and its environmental and public health impacts. I will contextualize this discussion with comparative case studies of the environmental and health effects of mining in Thailand and the Democratic Republic of the Congo. I will then examine the social justice implications of current mining practices and make recommendations for more just practices.

### **Environmental and Occupational Health Effects of Mining in Appalachia**

#### **Environmental Contaminants Associated With Coal Mining**

The negative health effects of coal mining in Appalachia are wide-ranging and extensively documented. Many health effects can be directly correlated with toxic agents released into the soil, air, and groundwater by mining activity, but are also related to the social environment of Appalachia, including human rights abuses and limited economic opportunities. Coal mining processes, particularly surface mining practices, unearth a slew of toxic substances

into the air, soil, and groundwater of the surrounding landscape. While many of these substances are not found in radically higher levels in the soil of coal mining areas compared to non-mining areas, people living in the vicinity of mining activities are at increased risk of exposure, primarily because of the dust released in the process (Dubey et al., 2011, as cited in Whitacre, Basta, Everett, Minca, & Daniels, 2013, p. 237). The following toxic agents are associated with coal mining activity in Appalachia: **aldehydes** (Ghose, 2007; Ghose & Majee, 2007); **aluminum** (McAuley & Kozar, 2006); **ambient air toxicants, which include unidentified particulate matter** (Ghose, 2007; Ghose & Majee, 2007; Trivedi, Mondal, Chakraborty, & Tewary 2010; Chaulya, 2004), **particulate matter less than 10 µm in diameter** (Trivedi et al., 2010; Ghose & Majee, 2007; Chaulya, 2004, Dubey et al., 2011 as cited in Whitacre et al., 2013; Mukherjee, Bhattacharya, & Saiyed, 2005), **carbon monoxide** (Ghose, 2007), **nitrogen dioxide** (Dubey et al., 2007 as cited in Whitacre et al., 2013; Ghose, 2007; Ghose & Majee, 2007), **and sulfur dioxide** (Dubey et al., 2007 as cited in Whitacre et al., 2013; Ghose, 2007; Ghose & Majee, 2007); **ammonia** (McAuley & Kozar, 2006); **arsenic** (Šebestová, Machovič, Pavlikova, Lelak, & Minarik, 1996; Black & Craw, 2001; De and Mitra, 2004; Wigginton, Mitchell, Evansc, & McSpirit, 2008; Gupta, 1999); **benzene** (Ghose & Majee, 2007); **beryllium** (Šebestová et al., 1996); **cadmium** (Dubey et al., 2007 as cited in Whitacre et al., 2013; Das & Chakrapani, 2011); **calcium** (McAuley & Kozar, 2006); **chloride** (Ghose & Majee, 2007); **chromium** (De and Mitra, 2004; Dubey et al., 2007 as cited in Whitacre et al., 2013); **cobalt** (De & Mitra, 2004); **copper** (De and Mitra, 2004; Dubey et al., 2007 as cited in Whitacre et al., 2013; Das & Chakprapani, 2011; Gupta, 1999); **iron** (Dubey et al., 2007 as cited in Whitacre et al., 2013; Brook et al., 2010; Wigginton et al., 2008; McAuley & Kozar, 2006); **lead** (De and Mitra, 2004; Dubey et al., 2007 as cited in Whitacre et al., 2013; Wigginton et al., 2008); **manganese** (Dubey



et al., 2007 as cited in Whitacre et al., 2013; Brook et al., 2010; McAuley & Kozar, 2006; Wigginton et al., 2008; Gupta, 1999); **mercury** (Lockwood, Welker-Hood, Rauch, & Gottlieb, 2009); **nickel** (Dubey et al., 2007 as cited in Whitacre et al., 2013; De & Mitra, 2004; Das & Chakrapani, 2011; McAuley & Kozar, 2006); **polycyclic aromatic hydrocarbons** (Ghose & Majee, 2007); **potassium** (McAuley & Kozar, 2006); **quartz** (McAuley & Kozar, 2006); **selenium** (McAuley & Kozar, 2006); **silica** (Dubey et al., 2007 as cited in Whitacre et al., 2013); **sulfur** (McAuley & Kozar, 2006); and **zinc** (De and Mitra, 2004; Dubey et al., 2007 as cited in Whitacre et al., 2013; Šebestová et al., 1996; Das & Chakrapani, 2011; Wigginton et al., 2008). Substances specifically associated with MTR mining operations include arsenic, chromium, cadmium, mercury, nickel, lead, thallium, selenium, polycyclic aromatic hydrocarbons, ammonium-nitrate, iron, and manganese (Ahern et al., 2011; Hendryx, O'Donnell, & Horn 2008). These agents are listed in Table A1, along with possible methods of exposure and health effects.

### **Exposure Pathways**

Inhalation, ingestion, and dermal absorption are the three possible methods of exposure of substances to the human body (United States Environmental Protection Agency, 2011). Some substances associated with coal mining activity are found in soil and dust, leading primarily to inhalation and dermal exposure, while others are found in groundwater, leading to ingestion (Table A1, Whitacre et al., 2013). Fugitive dust, or dust that moves off mining sites, originates from blasting, drilling, and wind erosion (Whitacre et al., 2013). Up to 80% of exposure to toxic agents from soil and dust results from the transportation of coal when coal is loaded and unloaded into vehicles or when dust is generated from driving on unpaved roads (Ghose, 2007). Acid mine drainage is the primary cause of increased amounts of many toxic substances in the

groundwater of mining regions. When sulfides in abandoned mines and in rocks of blasted mine sites come into contact with water and oxygen in the air, they become acidic, which then causes other toxic agents, including many of the substances listed in Table A1, to leach into the groundwater from the soil (Whitacre et al., 2013). A variety of other coal extraction and processing activities, including mine fires and coal burning, result in increased exposure to toxic substances found in coal. These multiple exposure pathways provide a direct connection between coal mining activity and the negative health effects of living in mining regions of Appalachia.

### **Physical-Environmental Health Effects**

The negative health effects of environmental contamination from coal mining activity are as widespread and varied as the toxins themselves. A study conducted by Ahern and colleagues (2011) found that the rate of birth defects was significantly higher overall and for six out of seven types of anomalies (circulatory/respiratory, central nervous system, gastrointestinal, urogenital, musculoskeletal, and other conditions) in MTR mining areas compared to other coal mining areas and non-mining areas of Appalachia. Chromosomal anomalies were the only type of birth defect of the seven anomalies studied not found to affect residents of MTR mining areas of Appalachia at a higher rate than other coal mining areas and non-mining areas. The geographic disparity in instances of birth defects can be partially attributed to socioeconomic disadvantages and their associated risks, but are also independently associated with water and air pollution caused by mining practices (Ahern et al., 2011). Birth defects and low birth weight are associated with unidentified particulate matter in the air, carbon monoxide, nitrogen dioxide, sulfur dioxide, arsenic, cadmium, lead, and mercury (Table A1, Whitacre et al., 2013).

Lung cancer mortality has been found to be significantly higher in Appalachia compared to other areas of the United States, even after access to healthcare based on insurance coverage

and number of doctors per capita are controlled for (Hendryx et al., 2008). Elevated mortality from lung cancer was specific to mining areas of Appalachia, as mortality due to lung cancer was not significantly higher than average in non-Appalachian areas with heavy coal mining (Hendryx et al., 2008). This high mortality from lung cancer may be a result of the high population density in coal mining areas of Appalachia compared to other coal mining areas, as well as the prevalence of surface mining in Appalachia (Hendryx et al., 2008).

In addition to lung cancer, total cancer mortality has been correlated with proximity to various mining activities in West Virginia, including injection sites, preparation plants, impoundment sites, and mines, as well as MTR mining areas more generally (Hendryx, Fedorko, & Anesetti-Rothermel, 2010; Hendryx, Wolfe, Luo, & Webb, 2012b). Cancer is associated with the presence of airborne particulate matter less than 10  $\mu\text{m}$  in diameter, arsenic, benzene, beryllium, cadmium, chromium, cobalt, nickel, polycyclic aromatic hydrocarbons, and silica (Table A1, Whitacre et al., 2013).

Cancer is not the only cause of increased mortality in Appalachia. Additional studies demonstrate the connection between increased mortality from chronic heart, lung, and kidney disease and coal production, measured by tons of coal produced per county (Hendryx, 2009; Hendryx & Zullig, 2009). Cardiovascular disease is associated with aldehydes, unidentified particulate matter in soil and dust, particulate matter less than 10  $\mu\text{m}$  in diameter, carbon monoxide, nitrogen dioxide, sulfur dioxide, ammonia, cadmium, copper, iron, lead, mercury, nickel, polycyclic aromatic hydrocarbons, potassium, quartz, sulfur, and zinc, (Table A1, Whitacre et al., 2013). A recent study by Knuckles and colleagues (2012) demonstrates that microvascular dysfunction is largely a result of Nitric Oxide-mediated vasodilation, identifying an important mechanism for cardiovascular disease among residents of coal mining regions of

Appalachia. Asthma is associated with unidentified particulate matter in soil and dust, particulate matter less than 10  $\mu\text{m}$  in diameter, and sulfur dioxide (Table A1, Whitacre et al., 2013). Kidney disease is associated with aluminum, arsenic, beryllium, cadmium, chromium, lead, mercury, polycyclic aromatic hydrocarbons, and silica (Table A1, Whitacre et al., 2013).

Additional more specific conditions, including chronic obstructive pulmonary disease (COPD) and hypertension, occur at higher rates and cause increased hospitalization among residents of West Virginia living in proximity to coal production (Hendryx & Ahern, 2008; Hendryx, Ahern, & Nurkiewicz, 2007). Hypertension is associated with unidentified particulate matter in soil and dust, carbon monoxide, arsenic, cadmium, lead, and mercury (Table A1, Whitacre et al., 2013). Residents of coal mining counties in Appalachia also experience higher rates of tooth loss than non-Appalachian mining counties and counties of Appalachia without mining activity, even after risk factors such as rural setting and socioeconomic status are controlled for (Hendryx, Ducatman, Zullig, Ahern, & Crout, 2012a). Tooth decay and loss are associated with arsenic, cadmium, lead, and manganese (Table A1, Hendryx et al., 2012a).

### **Socio-Environmental Health Effects**

In addition to the physical-environmental health issues of coal mining in Appalachia—those that are directly correlated with toxic agents released by coal mining, processing, and transportation—populations in areas of Appalachia also suffer socio-environmental health effects—the indirect health consequences of coal mining activity. Populations of Appalachia experience disproportionately higher morbidity and mortality rates compared to the rest of the country that cannot be explained by direct exposure to contaminants alone (Zullig & Hendryx, 2010). In 2007, one of the lowest life expectancies in Appalachia was in McDowell County, West Virginia, where the average life expectancy at birth was 66.3 years for men and 74.7 years

for women (Kulkarni, Levin-Rector, Ezzati, & Murray, 2011). The national average life expectancy at birth in the United States was 75.6 years in 2007 (Kulkarni et al., 2011). In 2007, the life expectancy at birth of males in McDowell County was about the same as for people living in Cambodia, El Salvador, Iraq, and Fiji (Kulkarni et al., 2011; The World Bank, 2014a). Females born in 2007 in McDowell County can expect to live about as long as people born in the Dominican Republic, Jordan, Kuwait, Samoa, and Tonga in the same year (Kulkarni et al., 2011; The World Bank, 2014b). Males in McDowell County had a worse chance of surviving to age 67 than people living in Bangladesh, the Dominican Republic, Egypt, Guatemala, Nicaragua, Tonga, and many other developing countries (Kulkarni et al., 2011; The World Bank, 2014a). Coal production has been found to exacerbate health disparities in Appalachia (Zullig & Hendryx, 2010). Self-rated health and health-related quality of life are significantly reduced in residents of counties in Appalachia compared with residents of other counties in the United States. Additionally, self-rated health and health-related quality of life are reduced in residents of coal-mining counties of Appalachia compared with residents of counties without coal mining (Zullig & Hendryx, 2010). People living in the heaviest mining areas of central Appalachia are at greater risk for major depression and severe psychological distress compared to other areas of Appalachia and the rest of the United States (Zullig & Hendryx, 2010). These socio-environmental health issues may be related to human rights violations that occur in conjunction with mining activity (Dullin, Ryan, & Franko, 2009).

There are numerous other health concerns that fall loosely under the umbrella of physical-environmental and socio-environmental health burdens. These include health effects associated with increased flooding in Appalachia as a result of greater mining activity and inadequate reclamation efforts (Ferrari, Lookingbill, McCormick, Townsend, & Eshleman, 2009;

Palmer, 2010); deaths and adverse health effects of slurry impoundment leaks, such as the Buffalo Creek Disaster of 1972 that killed 125 people and left thousands of others homeless when the dam of a 132 million gallon coal slurry impoundment burst in Logan County, West Virginia (Erikson, 1976); accidents of coal trucks on haul roads, including 137 fatalities between 1995 and 2011 involving coal haul trucks (Zhang, Kecojevic, & Komljenovic, 2014); coal processing chemical spills, such as the January 2014 spill of 4-methylcyclohexanemethanol into West Virginia's Elk River, leaving 300,000 residents without drinkable water (Gabriel, 2010); and coal mining blasting accidents, which caused 20 fatalities between 1978 and 1998 (Verakis & Lobb, 2001 as cited in Kecojevic & Radomsky, 2005). Coal production and the economic vulnerability of coal-producing areas of Appalachia have also been implicated in the region's prescription drug crisis (Leukfeld, Walker, Havens, Leedham, & Tolbert, 2007; McMillon, 2014). Between 1999 and 2004, West Virginia had a 550% increase in the number of unintentional poisoning deaths, the largest increase in the country, which were largely due to prescription drug overdoses (Centers for Disease Control and Prevention, 2007). Socio-environmental health effects of mining in Appalachia are summarized in Table A2.

### **Occupational Health Effects**

In addition to the deleterious environmental health effects of mining, occupational health hazards plague miners in Appalachia. As early as the 1960s, the National Institute for Occupational Safety and Health (NIOSH) reported poorer general health of Appalachian coal miners compared to the general public (Patel et al., 2001). Coal miners in Appalachia are at risk of developing heart disease, chronic obstructive pulmonary disease, lung cancer, and pneumoconiosis as a result of mining conditions (Hendryx et al., 2008). Coal Workers' Pneumoconiosis (CWP), colloquially known as black lung disease, is a chronic condition caused

by dust inhalation leading to irritation of the alveoli that results in permanent lung damage (Laney, Wolfe, Petsonk, & Halldin, 2012a). The most severe form of CWP is Progressive Massive Fibrosis, or PMF (Laney et al., 2012a). In an effort to protect miners exposed to excessive dust from developing CWP, the government included provisions in the Coal Mine Health and Safety Act in 1969 that set maximum permissible limits of dust inhalation in underground and surface mines. It also established a protocol for monitoring the development of pneumoconiosis in underground coal miners (Laney et al., 2012a). The enforcement of these measures was effective in bringing about a decline in CWP in the two decades following the Coal Mine Health and Safety Act. However, an abrupt increase in CWP has been observed within the last decade, possibly as a result of increased surface mining activity (Laney et al., 2012a).

In a study conducted by Laney and colleagues, it was found that miners who had worked at surface mines, including some who had never worked in underground mines, still developed pneumoconiosis, some with advanced cases (Laney et al., 2012a). This lies in opposition with the previously accepted belief that only underground coal miners were at risk for developing pneumoconiosis. More surface miners from Appalachian states (Kentucky, Virginia, and West Virginia) were found to have developed CWP than surface miners from 13 other states (Laney et al., 2012a). Prevalence of CWP was found to decrease as mine size increased; this is not a direct result of the size of the mine, but rather results from issues associated with small mines, such as limited resources for dust reduction (Laney, Petsonk, Hale, Wolfe, & Attfield, 2012b; Suarathana, Laney, Storey, Hale, & Attfield, 2011). A recent report by Chris Hamby (2013) revealed systematic efforts by a network of lawyers and doctors to hide reports of black lung disease, denying miners medical care and benefits. Perhaps most shocking about this report is that

members of this network worked for highly acclaimed institutions: law firm Jackson Kelly PLLC, U.S. News and World Report's top mining law firm in the nation in 2011-2012, and the Johns Hopkins Medical Institutions (Hamby, 2013a,b).

Noise-induced hearing loss, or NIHL, is another major health issue facing Appalachian coal miners. NIHL is characterized by slow, progressive loss of hearing sensitivity. Long-term exposure to high-level noise results in permanent hearing loss for which there is no medical cure (Patel et al., 2001). According to the Occupational Safety and Health Administration (OSHA), employees are at risk of hearing loss if they are exposed to an average of 85 decibels over an 8-hour period every day. Overexposure can be prevented with the use of hearing protection devices, or HPDs (Patel et al., 2001). Mining employees handle equipment that exposes them to noise at an average level of 80 to 120 decibels over an 8-hour workday, putting them at high risk for NIHL (Patel et al., 2001). Over 90 percent of coal miners report experiencing moderate to severe hearing loss by age 55 (Murray-Johnson et al., 2004). Efforts to remedy the trend of increased hearing loss of miners in Appalachia began in the 1980s, and included measures by the Mine Safety and Health Administration to change laws and enforce control on how machines were manufactured to reduce noise output. While the laws were sufficient for protecting miners' hearing, they were largely ineffective because they did not involve input from miners; most miners did not comply with the mandates to wear HPDs because of preexisting misconceptions about the HPDs (Murray-Johnson et al., 2004; Patel et al., 2001). The occupational health effects of coal mining are summarized in Table A3.



### **Comparative Case Studies: The Global Context of Natural Resource Extraction**

Comparing the living conditions of Appalachia to those in developing countries is problematic, as “it denies the interconnectedness of Appalachia and the environmental destruction going on there with the everyday life of the United States and makes this destruction easier to ignore” (Scott, 2010, p. 63). A more appropriate comparison is that of Appalachia as a peripheral economic region within the United States and the global economy. The natural resource extraction that occurs in Appalachia, a rural and less densely populated area, flows towards the core regions, with larger populations in smaller areas that hold economic and political power over the periphery (Burns, 2007). Shirley Burns likens Appalachia and other peripheral areas to colonies:

Like colonies, the periphery supplies raw materials cheaply so that the core can benefit from the production of goods and services for the national and global market. Any attempt to alter this relationship leads to mobilization by the powerful core against the weaker periphery as the core seeks to maintain its control. (Burns, 2007, p. 2).

Because of the extreme costs to those living in mining areas, it cannot be said that Appalachia supplies coal “cheaply.” The devastating environmental and health effects of mining activity are external costs; the producing regions of coal, not the consuming regions, bear the burdens of its extraction. This is true of other peripheral regions that apply resources to the core. To contextualize the experiences of Appalachians in coal mining regions, I will explore the health effects of mining in two countries that also lie in the economic periphery: Thailand and the Democratic Republic of the Congo.

#### **Gold Mining, Thailand**

**Mining process.** Like coal mining in Appalachia, Thailand has a long history of gold

mining. There are four major deposits of gold in Thailand. These include the Tha Thako deposit in Lop Buri province, the Kabin Buri and Ban Bo Nang Ching deposits in Prachin Buri province, and the Toh Moh deposit in Narathiwat province (Figure A1; Shawe, 1984). However, it has been speculated that there are gold deposits in every province in Thailand except in the northeast highlands and Chao Phraya region (*Thailand: Mining*, 2003; Figure A1). Gold is processed in an amalgamation process in which gold ore and mercury are heated together. The mercury extracts impurities from the gold and is evaporated, leaving a relatively pure product (Farrell, Sampat, Sarin, & Slack, 2004). The mercury is often removed in an open burning process that releases mercury vapor into the air (Umbangtalad, Parkpian, Visvanathan, DeLaune, & Jugsujinda, 2007), although a retort can be used to recycle the mercury vapor (Veiga, Maxson, & Hylander, 2006). The mercury amalgamation process is used in artisanal gold mining in over fifty countries (Veiga, Maxson, & Hylander, 2006). Alternatively, cyanide may be sprayed on the gold ore to separate the pure product from waste (Farrell et al., 2004). Gold miners are at severe risk of being exposed to large amounts of mercury vapor or cyanide because of the way in which the gold is processed. The contamination of groundwater, air, and soil with toxins like mercury and cyanide is a major environmental concern in mining areas in Thailand, as mining contributes to the physical disturbance of land and causes spilled mine tailings, dust emission, and acid mine drainage (Nobuntou et al., 2010).

**Environmental and mining legislation.** Mining legislation in Thailand consists of the Minerals Act of 1967, which was most recently amended in 2002. Laws governing mining in Thailand place responsibility on local governments to subjectively determine what is environmentally harmful and what puts the public health of local populations at risk (Kititasnasorchai & Tasneeyanond, 2000). However, environmental laws in Thailand are much

more thorough and specific. The primary structure of environmental policy in Thailand is outlined in the Enhancement and Conservation of National Environmental Quality Act of 1975 (Kititasnasorchai & Tasneeyanond, 2000). This act created a centralized government agency under the Ministry of Science, Technology, and Energy (MSTE) to monitor environmental issues, called the Office of the National Environment Board (Kititasnasorchai & Tasneeyanond, 2000). The act also gave the MSTE power to create national environmental standards and methods for monitoring them (Kititasnasorchai & Tasneeyanond, 2000).

Thailand's Public Irrigation Act of 1942 has implications for mining activity as it has a segment regulating water pollution. Section 28 of the Public Irrigation Act is as follows:

No person shall dispose garbage, rubbish, or any other form of waste into irrigation water, nor shall make the water harmful to agriculture and consumption. No person shall dispose water or liquid which is contaminating to natural water, or chemical substance into irrigation water in a manner which may be harmful to agriculture, or public health.

Violation of the first paragraph of this Section is subjected to imprisonment not exceeding three months or fine not exceeding two thousand Baht or both, and violation of the second paragraph is subjected to imprisonment of not exceeding two years or fine of not exceeding one hundred thousand Baht, or both. (Kititasnasorchai & Tasneeyanond, 2000, p. 12)

Additionally, it is written in the Constitution of the Kingdom of Thailand of 2007 that

Any project or activity which may seriously affect the quality of the environment, natural resources and biological diversity shall not be permitted, unless its impacts on the quality of the environment and on health of the people in the communities have been studied and evaluated and consultation with the public and interested parties have been organized, and opinions of an independent organization, consisting of representatives from private

environmental and health organizations and from higher education institutions providing studies in the field of environment, natural resources or health, have been obtained prior to the operation of such project or activity. (May, 2013, p. 55)

Local governments are responsible for enforcing mining laws, so each locality has different standards of what is considered harmful to people, plants, animals, and property. Additionally, local governments are free to either permanently or temporarily halt mining activity that is considered harmful, but there are no consequences for officials who fail to comply with Environmental Impact Assessment rules (Kititasnasorchai & Tasneeyanond, 2000). The process of holding public hearings to allow activities detrimental to health and the environment is highly susceptible to corruption (Keegan, 2012). For example, the Australian-owned mining company Tungsum Limited reportedly paid off the village headman of Na Na Bung village in Loei province to change votes in favor of the proposed mine's construction (Keegan, 2012).

**Environmental exposure.** Like heavily mined areas of Appalachia, gold mining areas in Thailand are affected by contamination of groundwater, air, and soil with toxic substances as a result of mining activity. Mining areas have leaked toxic heavy metals, including lead, mercury, cadmium, and arsenic, into the surrounding landscape and groundwater (Nobuntou et al., 2010). In a mining area of Kanchanaburi province, lead concentrations in agricultural soil was found to be between 137.8 and 613.5 mg/kg dry weight, ranging far above the maximum allowable concentration of 300 mg lead/kg dry weight of agricultural soil. Lead concentration in soil was inversely proportional to the distance from the mining area (Nobuntou et al., 2010). Similarly, the concentration of mercury in soil was found to be elevated near the Phanom Pha gold mining area located in Phichit province, and was inversely proportional to distance downstream from the mining area (Umbangtalad et al., 2007). Plant uptake of toxic metals varies, but cadmium has

been found in rice at higher than allowable concentrations, which poses a serious public health risk (Nobuntou et al., 2010). Thailand is one of the major countries affected by high concentrations of arsenic in groundwater (Singh, Kumar, & Sahu, 2007). The maximum concentration limit for arsenic in Thailand is less than 0.01 mg/l for drinking water and 3.9 mg/kg for soil used for agriculture, as mandated by the Office of National Environmental Board of Thailand (Weerasiri, Wirojanagud, & Srisatit, 2012). A study by Weerasiri and colleagues (2012) found arsenic levels in soil in Loei province between 1.21 and 56.17 mg/kg of soil, alarmingly higher than the maximum allowable concentration. Arsenic in soil was subsequently taken up by plants (Weerasiri et al., 2012), and has also been found at much higher than legal maximum limits in surface water in the proximity of mining areas (Weerasiri, Wirojanagud, & Srisatit, 2013). Not only are people affected by contaminated water in the vicinity of mining areas, but everyone living near the watershed downstream of mining areas may experience adverse effects of contaminated drinking water. This is of considerable concern during periods of heavy precipitation (Nobuntou et al., 2010). Also concerning is that arsenic contamination was found outside the catchment area of the gold mine studied (Weerasiri et al., 2012).

**Environmental health effects.** While poorly reported in the literature, media reports indicate negative environmental and health effects of gold mining in Thailand. Recent reports have focused on areas of Loei province, where low crop yields, fish kills, and a slew of health conditions affecting residents including “chronic headaches, eye pain, blackouts, vertigo and abnormal rashes” have been reported (Ford, 2014). In response to findings by the Ministry of Health that residents in the region of the gold mine had mercury and cyanide poisoning, the provincial government began supplying the community with clean water (Ford, 2014). Other common health issues that remain unstudied in mining regions of Loei province and that are

associated with chronic arsenic exposure include skin lesions, cardiovascular disease, encephalopathy, chronic lung disease, cerebrovascular disease, reproductive disease, adverse renal effects, developmental abnormalities, hematological disorders, diabetes mellitus, low birth weight and other adverse pregnancy outcomes, and cancers of numerous organs (Bolt, 2012; Singh et al., 2007). Arsenic contamination of drinking water has led to long-term arsenic exposure in certain populations. Cases in which arsenic has been equal to or exceeded 50 µg per liter of drinking water have been linked with increased risk of skin cancer, lung cancer, bladder cancer, and kidney cancer, as well as hyperkeratosis and pigmentation changes in skin (Bolt, 2012). Arsenic in drinking water has also been associated with growth retardation in children, spontaneous abortion, stillbirth, and infant mortality (Singh et al., 2007). Additional health problems may be caused by the combined exposure of arsenic with other inorganic and organic compounds, which may occur in mining areas (Bolt, 2012). Because of the scores of health issues associated with arsenic exposure, arsenic contamination should be regarded as a serious public health concern.

**Occupational health effects.** Because of the way gold is mined and processed, mercury exposure is a major concern for miners (Eisler, 2002). A study conducted by Umbangtalad and coworkers in the Phanom Pha gold mining area in Phichit province revealed that urine samples of miners and schoolchildren living near the mining area indicated higher exposure to mercury than a control group, but at levels that did not exceed the occupational standard or maximum permissible limit (2007). No water samples taken in the area exceeded the government established limit of 5 µg/L, though it was found that inhalation and drinking water were likely sources of mercury exposure (Umbangtalad et al., 2007). However, miners working in the area

closest to where the gold was processed were found to have mercury exposure up to one hundred times the recommended level (Umbangtalad et al., 2007).

### **Coltan Mining, Democratic Republic of the Congo**

**Mining process.** Coltan, a term unique to Central Africa for columbite-tantalite or columbo-tantalite, is a metallic ore containing the chemical elements Niobium (Nb), also called Colombium (Cb), and Tantalum (Ta). Tantalum, atomic number 73, is a refractory metal with a high melting point (2,996 °C) and boiling point (5,425 °C), properties that make it incredibly heat-resistant (Hayes & Burge, 2003). Tantalum is twice as dense as steel, resists deterioration from acids and caustic substances as well as glass does, and stores and releases electrical charge and heat (Tegera, Mikolo, & Johnson, 2002). Additionally, it is more easily worked and welded than most other refractory metals. This combination of valuable properties makes tantalum perfectly suited for several applications, which can be grouped into four major areas: electrical devices, such as capacitors used in mobile phones, video cameras, computers, pagers, and playstations; high-temperature applications, such as aircraft engines; surgical implants, including perforated strips and screws to hold broken bones together, dental implants, and joint replacement components; and applications in handling corrosive materials (Hayes & Burge, 2003). The electronics industry uses approximately 60 percent of tantalum produced for capacitors (Tegera et al., 2002).

There are four main sources of tantalum: mine production, which accounts for the majority of tantalum production; synthetic concentrates from tin slag; recycled material from processors' internal waste; and stockpiles (Hayes & Burge, 2003). Australia is the world's largest producer of mined tantalum; however, about 80 percent of the world's tantalite reserves

are found in the Democratic Republic of Congo (DRC), specifically on the eastern border of DRC in the vicinity of Kahuzi Biega National Park (Figures A2, A3; Nadira, 2007). Tantalum from the Democratic Republic of Congo is typically used only when there is a suddenly increased or particularly high demand for tantalum; however, demand for tantalum from the DRC will likely remain steady because of sustained growth in the electronics industry (Hayes & Burge, 2003). Other tantalum producers include Brazil, Burundi, Canada, China, Ethiopia, Malaysia, Nigeria, Russia, Rwanda, and Thailand, among many other smaller producers (Tegera et al., 2002).

Niobium, atomic number 41, also has high melting (2,468 °C) and boiling (4,742 °C) points (Kremer, 2000). The physical and chemical properties of this coltan element are very similar to those of tantalum (Kremer, 2000). Niobium is used in steel alloys, super alloys of aircraft turbine engines, superconducting magnets, and jewelry.

Anders Gustaf Ekenberg, a Swedish chemist, discovered tantalum in 1802, but the element was not distinguished as distinct from niobium until 1866 (Gagnon, 2012). Tantalum was first used commercially in the 1900's, when it was used in wire form as lamp filament (Hayes & Burge, 2003). Coltan was not exploited in the Democratic Republic of Congo until much later in the 20<sup>th</sup> century, when new technologies increased global demand. In 1976, the Belgian-Zairian firm Sominki (Société Minière du Kivu) formed in the North Kivu province of the DRC. The mining firms that merged to create Sominki originated from a concession Belgian King Leopold II granted to Belgian Baron Empain in 1902 (Tegera et al., 2002). Gold mining dominated Sominki's mining activities, but they also extracted coltan. The Zairian economy experienced a crisis in the 1980's, which forced Sominki to close many of their mining operations, at which time artisanal mining typical of current coltan exploitation began (Tegera et



al., 2002). Sominki regulated artisanal miners prior to complicated political unrest beginning in 1998 (Tegera et al., 2002). The illegal exploitation of natural resources by foreign armies now dominates coltan mining in the DRC (Prendergast & Lezhnev, 2009).

In Central Africa, coltan resides in streambeds, alluvial deposits, and soft rock. The largest coltan reserves are located in the eastern Democratic Republic of Congo in the Kivus' hills and forests (Nadira, 2007). Artisanal miners work in teams to extract the ore. According to research conducted by Stephen Jackson (2003), the following method is used to extract coltan:

After digging a few metres, one person bails water from the hole, one person dig up from the hole onto a pile by the sluice (a flat, clay-lined pit with walls made of slates on three sides), one refills the sluice periodically with the materials from the pile, and one sluices, continuously turning and scraping the materials with a spade. The dirt runs away in the water; turning it brings the bigger stones to the top to be skimmed. The heavy ore, in tiny pebbles, sinks to the bottom. (Jackson, 2003, p. 9)

The miners, called *creuseurs* or *boulonneurs*, then sieve the pebbles through 5mm mesh (Jackson, 2003). The resulting gravel is washed in a bowl until heavy particles of coltan are all that remain. This coltan grit is measured in 7oz units and packaged into nylon bags, which are sewn shut and carried in a rucksack made from vines of the liana plant (Hayes & Burge, 2003). The miners pay military forces controlling the land and local authorities in spoonfuls of coltan. Then, porters are paid in coltan to carry 20kg (44lbs) bags of coltan to a nearby trading center, called a *comptoir* (Figure A4, Hayes & Burge, 2003). The trading center tests the coltan ore using spectrographic analysis to determine its purity. There is no system in place to ensure honesty in reporting the purity of the ore, so porters easily cheat miners from earning a fair price.

After the coltan is tested, traders, called *negotiateurs*, buy the ore. Some traders obtain a license, which costs up to USD 40,000 per year but fluctuates in price according to coltan demand. Licensed traders are assigned to work for a specific trading center. 90 percent of traders operate without a license (Prendergast & Lezhnev, 2009), smuggling coltan to Rwanda by road or air (Hayes & Burge, 2003). Unlicensed traders operate with the help of several intermediaries who transport of coltan ore on its way from the remote mining site to a major town (Jackson, 2003). First, a local intermediary journeys to the mine site to trade supplies or pay cash, either US Dollars or Congolese francs, for the ore. This intermediary transports the ore to a major local market to be sold to a second intermediary (Prendergast & Lezhnev, 2009). The ore purchaser at the market then arranges transport to a larger town, most likely Goma or Bukavu which each have about 100 trading houses (Figure A5, Prendergast & Lezhnev, 2009), or straight to Kigali, Rwanda (Jackson, 2003). Corruption occurs throughout the process.

In the major towns, mineral-purchasing organizations buy ore from the secondary intermediaries. Workers process the ore by crushing, washing, grading, separating, extracting, and assaying it. Finally, they pack the processed ore into barrels and transport the barrels by air to Europe (Jackson, 2003). The cargo may then be transported to a processing plant in Europe, Asia, or North America (Hayes & Burge, 2003). Major processors of tantalum include the American firm Cabot Corporation; a German firm H.C. Starck, which has branches in Japan, Thailand, Germany, and the United States; and several firms owned by the Chinese government (Hayes & Burge, 2003). At processing plants, impurities are removed and the ore is formed into powder, which may then be processed into wire, sheet, or alloy (Prendergast & Lezhnev, 2009). Metal from different sources mixes together at processing plants, which makes tracking conflict metals nearly impossible. Processing plants sell the processed metal to various manufacturers,

including electronics component manufacturers, satellite and armament manufacturers, and other end-users (Jackson, 2003). Traders act as intermediaries between producers and processors and between processors and manufacturers. Some members of the Tantalum-Niobium International (TIC) Study Center's trader list include A&M Minerals & Metals Ltd in the United Kingdom, Chori Co Ltd in Japan, and Plazaminerals in Switzerland (Hayes & Burge, 2003). Many of the end-user companies are tantalum capacitor manufacturers (Prendergast & Lezhnev, 2009), which sell products to electronics companies that account for 60 percent of tantalum consumption (Hayes & Burge, 2003).

**Environmental and mining legislation.** The main laws regulating mining activity in the Democratic Republic of the Congo are the Mining Code adopted in 2002 and the Mining Regulation adopted in 2003 (USAID, 2014). However, this legislation does not include regulation for artisanal mining. According to a USAID report (2014), "No uniform national standards and safeguards governing health and safety and good environmental practices are applied to small-scale and artisanal operations, and the miners are vulnerable to exploitation by government officials and military forces."

**Environmental and occupational health effects.** Coltan mining in the Democratic Republic of Congo has had devastating impacts on miners, locals, and the environment. Mining and metal refining operations have caused the following metals to be present in the urine of residents in higher levels than in non-mining areas: aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, selenium, tellurium, tin, uranium, vanadium, and zinc (Banza et al., 2009). Coltan miners are susceptible to inhaling and ingesting large quantities of dust containing coltan particles, exposing them to high levels of naturally occurring radioactive materials (Mustapha, Mbuzukongira, & Mangala, 2007). Mining accidents such as

landslides occur frequently, sometimes even daily. Armed groups controlling the mines cause many deaths and contribute to problems such as prostitution, polygamy, alcoholism, and rape of young girls (Tegera et al., 2002). These armed groups disproportionately victimize miners of particular ethnicities, especially Hunde miners (Jackson, 2003). Some men who profit from mining leave their wives and children and move to larger towns. Children have been dropping out of school at alarming rates to mine coltan. Sometimes miners are paid, though pay is unreliable and often unfair, while others are coerced into mining (Prendergast & Lezhnev, 2009). Population displacement in mineral-rich areas is common, with entire villages being emptied at times to make way for coltan production (Jackson, 2003). Large amounts of agricultural land have been abandoned because those who used to work in farming are flocking to more profitable jobs in mining (Tegera et al., 2002). This has caused increases in food prices, which can become prohibitively expensive (Costanzo, 2006).

**Additional environmental effects.** In addition to the injustices people face as a consequence of coltan mining, the environment also suffers. The Democratic Republic of Congo's Kahuzi-Biega National Park (Figure A3) overlaps with many coltan mines (Costanzo, 2006). While mining in the park is illegal, less than ten percent of the park is accessible to wardens and rangers, meaning the law cannot be enforced in most of the park (Costanzo, 2006). Armed factions mining coltan rule the rest (90 to 95 percent) of the park. Deforestation makes mining easier, wreaking havoc on the habitat of flora and fauna unique to the area. Elephants and the eastern lowland gorilla have experienced the brunt of habitat loss due to land clearance and environmental destruction (Duffy, 2010). Before coltan mining dominated Kahuzi-Biega National Park, gorilla populations were around 8,000 and elephant populations were around 3,600. Regions of the park are too inaccessible for data collection to be conducted, but estimates

indicate between 3,000 and 4,000 elephants were killed in the years between 1994 and 1999; the eastern lowland gorilla population may now be as low as 5,000 (Duffy, 2010). These population decreases can be attributed to habitat clearance for mining, water contamination from the coltan extraction process, and heavy poaching for bushmeat and ivory tusks. The killing of adult gorillas has led many baby gorillas to become orphaned, captured and sold as pets, but these young gorillas cannot survive without adequate parental care and socializing with other gorillas (Costanzo, 2006). Because of coltan mining, the eastern lowland gorilla will likely disappear from the area within ten to twenty years if no action is taken to protect their habitat.

### **Appalachia as a National Sacrifice Zone, the Slow Violence of Mining, and Seeking Health Care Justice through Fair Equality of Opportunity**

There are clear differences between coal mining in Appalachia, gold mining in Thailand, and coltan mining in the Democratic Republic of the Congo. Gold and coltan mining operations are often small scale artisanal mines, whereas coal mining is large-scale, highly mechanized, and heavily regulated. Gold is primarily used for jewelry, currency, and electronics; coltan has uses in electronics, high-temperature applications, and surgical implants; coal is primarily used as a source of energy. The laws governing mining in these areas vary widely, but corruption and cronyism run rampant in all three regions. Despite vast differences between Appalachia, Thailand, and the Democratic Republic of the Congo, mining regions of each of these locations share a history of marginalization and oppression within their respective countries as a result of natural resource extraction. Poor health in mining regions compared to the rest of the population is one type of externality of natural resource extraction and one manifestation of the pervasive

injustices that occur in these regions, injustices that make Appalachia a “sacrificial landscape” (Black, 2000).

A variety of factors make it possible for Appalachia to exist as a sacrificial landscape/sacrifice zone, terms used to describe regions whose destruction is justified by other benefits, like national interest for energy. The difficulty of sensationalizing in the media the injustices that occur in Appalachia is a key contributor. It has been found that when the media do not sensationalize a disease or illness, which often happens when diseases do not strike at the same time in the same place, it fails to garner widespread attention (Armstrong, Carpenter, & Hojnacki, 2008). The same can be said for incremental environmental degradation. The difficulty of grabbing the public’s attention with slowly developing injustice is articulated in Rob Nixon’s concept of slow violence. Slow violence is “a violence that occurs gradually and out of sight, a violence of delayed destruction that is dispersed across time and space, an attritional violence that is typically not viewed as violence at all” (Nixon, 2011, p. 2). Nixon asks critical questions about the challenge of environmental degradation and its impacts on public health:

In an age when the media venerate the spectacular, when public policy is shaped primarily around perceived immediate need, a central question is strategic and representational: how can we convert into image and narrative the disasters that are slow moving and long in the making, disasters that are anonymous and that star nobody, disasters that are attritional and of indifferent interest to the sensation-driven technologies of our image-world? How can we turn the long emergencies of slow violence into stories dramatic enough to rouse public sentiment and warrant political intervention, these emergencies whose repercussions have given rise to some of the most critical challenges of our times? (Nixon, 2011, p. 3)

Slow violence characterizes much of what occurs in Appalachia as a result of coal mining. However, even when disasters strike that have the potential to spark dialogue about the slow violence that occurs in Appalachia, stereotypes of the region prevent these critical conversations from happening. For example, when twelve out of thirteen trapped miners died in the Sago mine disaster of 2006, the media focused on the faith of the victims' loved ones, the resilience of the community, and the failure of the mining companies to communicate details of the rescue effort to the families—"a sentimental story of dashed hopes and a miraculous recovery"—which allowed conversations in the state and national media to avoid discussing the underlying problems of poor mining regulation, negligence, corporate greed, and miners' lack of political voice (Scott, 2010, p. 61). Scott elaborates:

...the national coverage of the Sago mine disaster was not focused on the kind of questions that would require specialized knowledge, such as the way that companies are using subcontractors and subsidiaries to avoid paying regulatory fines and hide their accumulating infraction records. In an indication of the superficiality required to represent Appalachia in an easily grasped way, MTR was entirely invisible in the coverage, which focused exclusively on underground mining. (Scott, 2010, p. 62)

Other popular conceptions of Appalachians as ignorant, white trash, hillbillies, and incestuous contribute to "epistemologies of disgust and social distance" that allow the oppressive circumstances of Appalachian life to be largely ignored by the public and contribute to a sense of inevitability about the fate of Appalachia (Scott, 2010, p. 63). In accepting the slow violence that occurs in Appalachia as inevitable and allowing the region to continue to exist a national sacrifice zone, regulators and consumers of Appalachian coal deny the right of residents of coal-producing regions to fair equality of opportunity, a necessary component of a just society.

### **Social Justice Implications**

It is not possible to completely close the gap in opportunities available to people due to the variation in natural talents and skills people are born with. However, we can minimize the gap in available opportunities that results from variation in social factors by providing fair equality of opportunity. For example, Alex may be born with a predisposition to enjoy playing sports and the genetics for an athletic build, while Bobby may not be born with either of these traits. Alex will likely have more opportunities in life than Bobby to play and excel in sports. Providing fair equality of opportunity does not aim to mitigate differences in opportunity due to differences in natural talents and skills. However, it does aim to lessen the opportunity gap among social groups that lack opportunities due to discrimination. Discrimination leads to the underdevelopment of the talents and skills of marginalized social groups, but providing fair equality of opportunity minimizes that effect. Access to equitable education is one component of fair equality of opportunity suggested by John Rawls' theory of justice. In a society in which race, class, and gender discrimination are present, providing equitable education lessens the extent to which differences in race, class, and gender affect the talents and skills one develops and one's range of available opportunities. In a similar way, as proposed by Norman Daniels, access to equitable health care is another necessary component for providing fair equality of opportunity (Daniels, 2008). Inequitable health care affects one's range of available opportunities. Providing equitable health care, like providing equitable education, contributes to establishing fair equality of opportunity. The injustice of coal mining activity in Appalachia lies in that it prevents Appalachians from accessing equitable health care, denying them their right to fair equality of opportunity.



### **Conclusion**

Residents of Appalachia lack full agency over their health status as a result of negative environmental health effects of mining activity. Residents of Appalachia rather than consumers of coal bear the burdens of coal mining. Coal mining causes negative health effects not only through creating a toxic physical environment, but through creating a toxic social environment of limited economic opportunity and human rights abuses. The failures of coal mining regulators, the medical system, and the legal system to mitigate the negative health effects of mining deny Appalachians their right to fair equality of opportunity. Stereotypes and misconceptions about Appalachia allow for its continued existence as a sacrificial landscape. In order to stop the slow violence that is perpetrated against residents of Appalachia and other marginalized mining areas, efforts must be made by consumers and regulators of natural resources, as well as institutions charged with protecting the welfare of citizens including the medical and legal systems, to promote justice through providing fair equality of opportunity.

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## Appendix

Table A1. The relationship between toxic agents of coal mining activity and negative health effects. (Whitacre et al., 2013)

Toxic Agents Possibly Caused by Coal Mining Activity	Method of Exposure	Direct Health Effects of Toxins (Conditions with Elevated Morbidity in Coal Mining Regions of Appalachia)
Aldehydes	Ground Water	Cardiovascular Disease
Aluminum	Ground Water	Kidney Disease
Ambient Air toxicants - Unidentified Particulate Matter - Particulate Matter Less than 10 µm in Diameter - Carbon Monoxide - Nitrogen Dioxide - Sulfur Dioxide	Soil and Dust	Asthma, Birth Defects and Low Birth Weight, Cardiovascular Disease, Hypertension Asthma, Cancer, Cardiovascular Disease Birth Defects and Low Birth Weight, Cardiovascular Disease, Hypertension Birth Defects and Low Birth Weight, Cardiovascular Disease Asthma, Birth Defects and Low Birth Weight, Cardiovascular Disease
Ammonia	Ground Water	
Arsenic	Ground Water, Soil and Dust	Birth Defects and Low Birth Weight, Cancer, Cardiovascular Disease, Hypertension, Kidney Disease, Tooth Decay
Benzene	Soil and Dust	Cancer
Beryllium	Soil and Dust	Cancer, Kidney Disease
Cadmium	Soil and Dust	Birth Defects and Low Birth Weight, Cancer, Cardiovascular Disease, Hypertension, Kidney Disease, Tooth Decay and Loss
Calcium	Ground Water	
Chloride	Soil and Dust	
Chromium	Ground Water, Soil and Dust	Cancer, Kidney Disease
Cobalt	Ground Water	Cancer
Copper	Ground Water, Soil and Dust	Cardiovascular Disease
Iron	Ground Water, Soil and Dust	Cardiovascular Disease
Lead	Ground Water, Soil and Dust	Birth Defects and Low Birth Weight, Cardiovascular Disease, Hypertension, Kidney Disease, Tooth Loss
Manganese	Ground Water, Soil and Dust	Tooth Decay
Mercury	N/A	Birth Defects and Low Birth Weight, Cardiovascular Disease, Hypertension, Kidney Disease
Nickel	Ground Water, Soil and Dust	Cancer, Cardiovascular Disease
Polycyclic Aromatic Hydrocarbons	Soil and Dust	Cancer, Cardiovascular Disease, Kidney Disease
Potassium	Ground Water	
Quartz	Ground Water	Cardiovascular Disease
Selenium	N/A	Cardiovascular Disease
Silica	Soil and Dust	Cancer, Kidney Disease
Sulfur	Ground Water	Cardiovascular Disease
Zinc	Ground Water, Soil and Dust	Cardiovascular Disease

Table A2. Socio-environmental health effects of coal mining.

Additional Indirect Health Effects Associated with Coal Mining in Appalachia
Lower Life Expectancy at Birth
Decreased Self-Rated Health
Decreased Health-Related Quality of Life
Depression
Severe Psychological Distress
Mining Accident Deaths (flooding, slurry impoundment leaks, blasting, coal haul trucks, etc.)
Increased Substance Abuse

Table A3. Occupational health effects of coal mining.

Additional Occupational Health Hazards Associated with Coal Mining in Appalachia
Chronic Obstructive Pulmonary Disease (COPD)
Pneumoconiosis (Black Lung Disease)
Noise-Induced Hearing Loss (NIHL)
Cardiovascular Disease (Increased Morbidity)
Lung Cancer (Increased Morbidity)

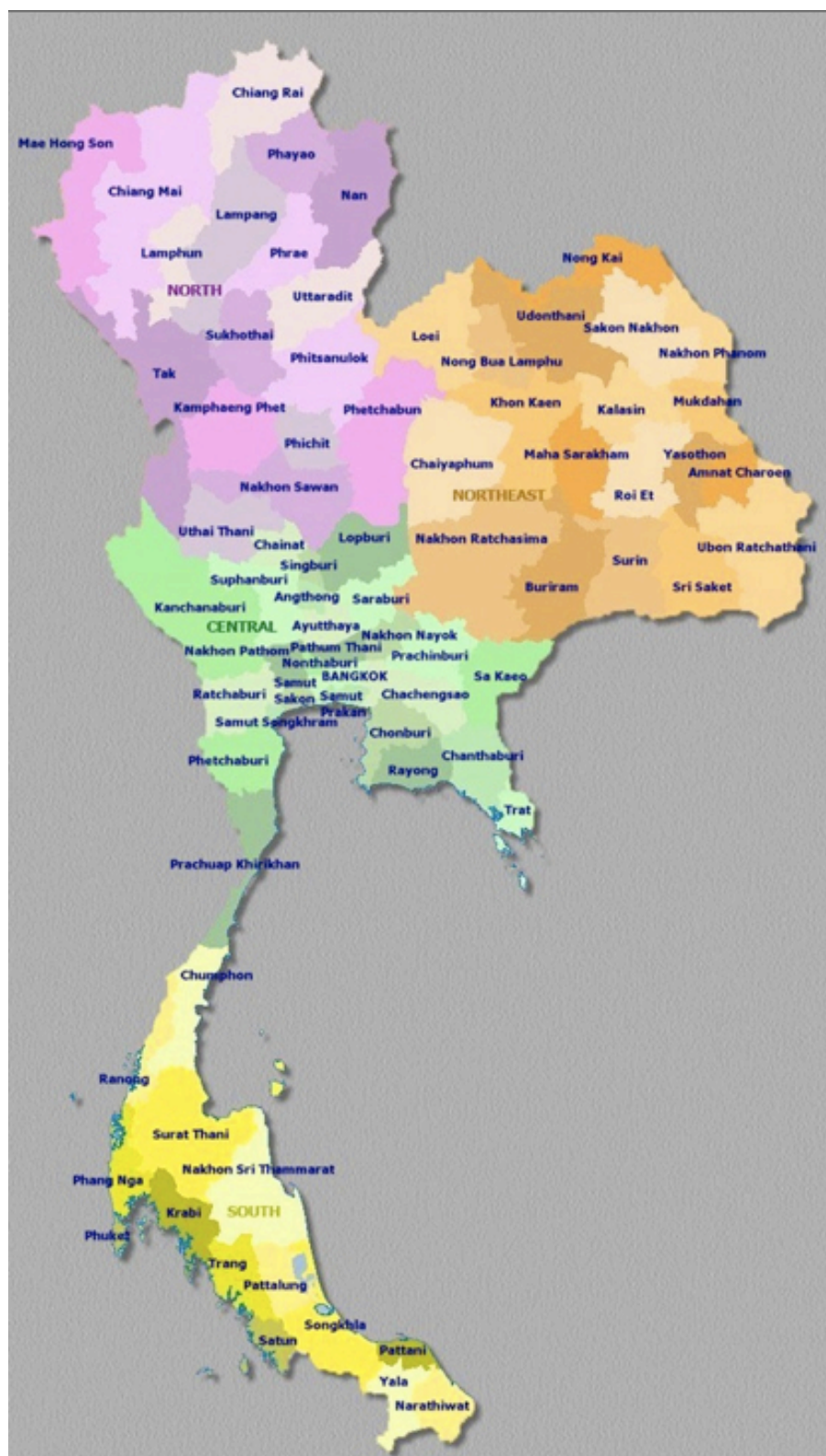


Figure A1. Map of the provinces of Thailand (TheThailandLife, 2011).



Figure A2. Kahuzi-Biega National Park in relation to Goma and Bukavu, Democratic Republic of Congo (Jane Goodall Institute of Canada).



Figure A3. Kahuzi Biega National Park, the location of deposits of coltan in the Democratic Republic of the Congo (Munn, 2007).



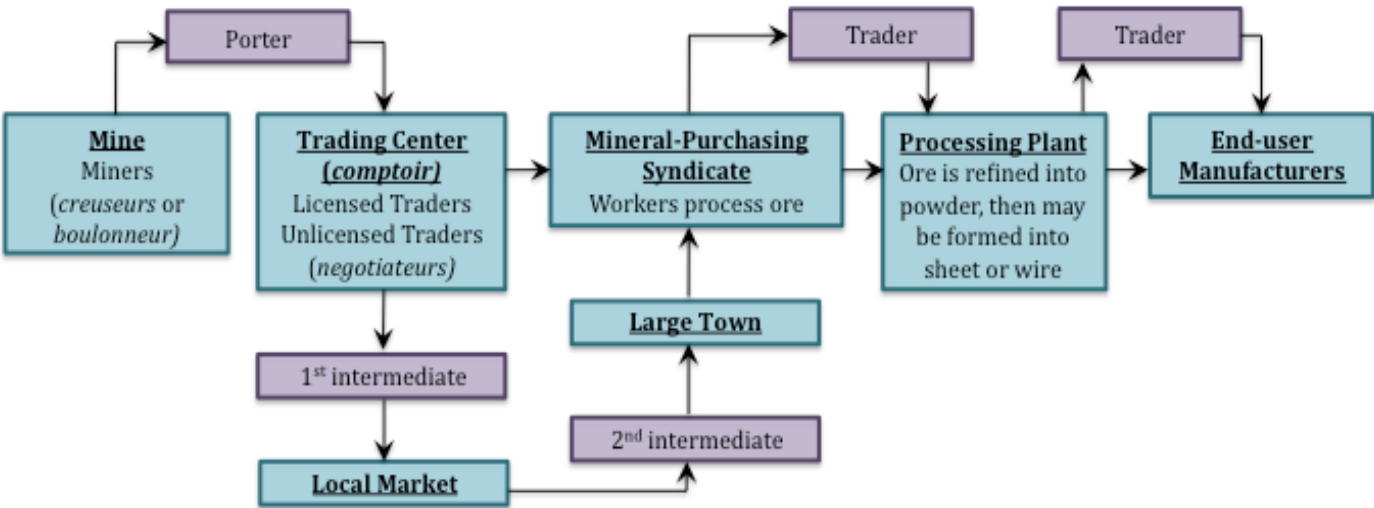


Figure A4. Coltan commodity supply chain.

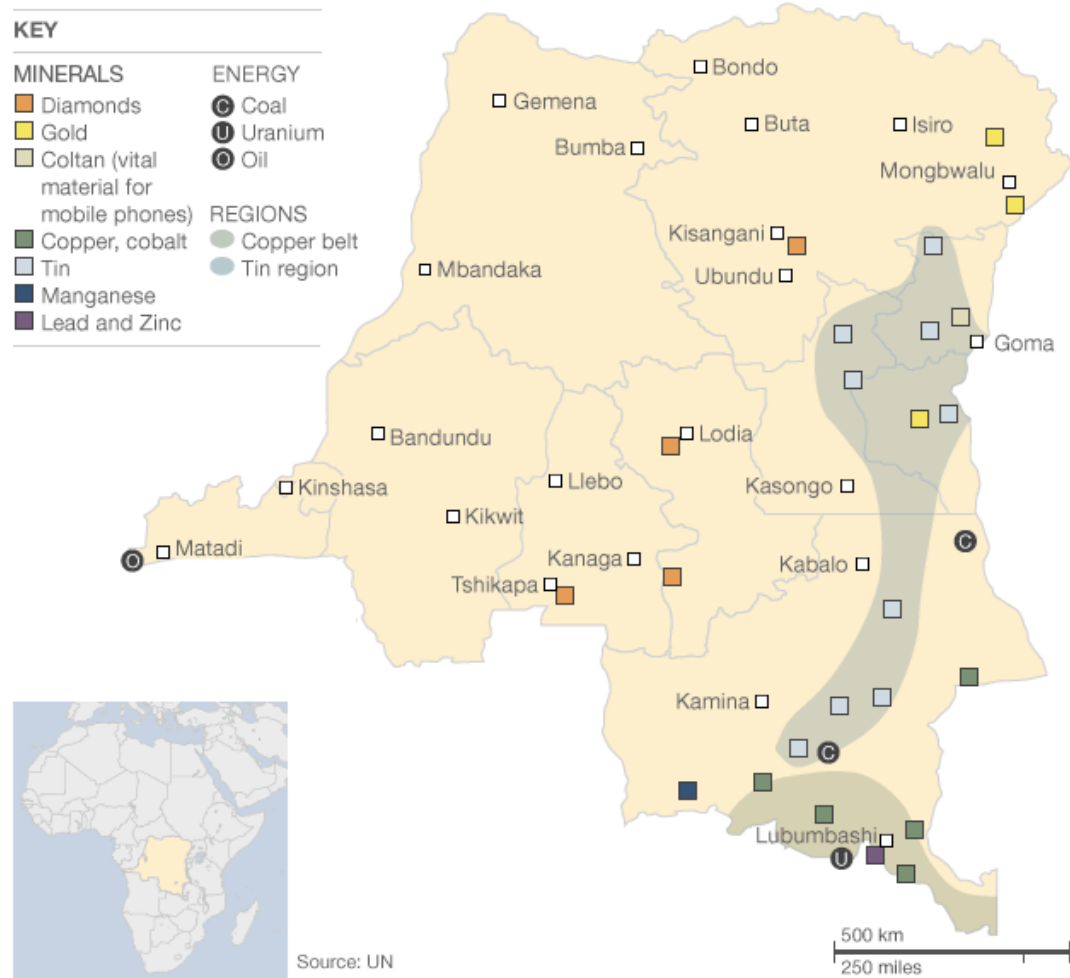


Figure A5. Mineral resources in the Democratic Republic of the Congo (BBC News Africa, 2012).